A STUDY OF LIQUID EXTRACTION

BY
STANFORD WILLIAM BRIGGS
B.S., California Institute of Technology, 1937
M.S., University of Illinois, 1938

AN ABSTRACT OF A THESIS
SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN
CHEMISTRY IN THE GRADUATE SCHOOL OF
THE UNIVERSITY OF ILLINOIS, 1941

URBANA, ILLINOIS
1941

A STUDY OF LIQUID EXTRACTION

BY

STANFORD WILLIAM BRIGGS

B.S., California Institute of Technology, 1937

M.S., University of Illinois, 1938

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN
CHEMISTRY IN THE GRADUATE SCHOOL OF
THE UNIVERSITY OF ILLINOIS, 1941

URBANA, ILLINOIS

1941

ACKNOWLEDGMENT

The author wishes to express his appreciation for the advice of Professor E. W. Comings under whose direction this investigation has been made. He is also indebted to the several students in the department who have given assistance in various parts of the study.

A STUDY OF LIQUID EXTRACTION

Introduction

Extraction has been increasingly utilized in separation processes in recent years. The general theory of extraction has received considerable attention, but more information of an experimental nature is required concerning equilibria in typical liquid systems and the rates at which equilibrium is approached.

The present problem consisted of a study of equilibria over a temperature range, in the system docosane-1,6-diphenyl-hexane- furfural, and in the system acetone-water-benzene; and an investigation of interphase mass transfer rates in wetted-wall and packed columns.

Equilibria in Three Component Liquid Systems

Binodal curves for the two systems were constructed from solubilities determined by sealing measured amounts of the components in a tube and observing the temperature at which the solution became heterogeneous.[1] The curves for the system docosane-diphenylhexane-furfural are shown in Fig. 1. The curves for the system acetone-water-benzene are shown in Fig. 2.

Tie lines were determined by measuring the refractive indices of the individual phases taken from the two phase mixtures at equilibrium. They are shown in Fig. 1 for the system docosane-diphenylhexane-furfural. Conjugate lines[3] represent the tie lines for the system acetone-water-benzene in Fig. 2.

The equilibria data obtained indicates that temperature effects solubilities and tie-lines in a regular manner. Le Chatelier's Principle and the Second Law of Thermodynamics are of use in predicting the effect.

A number of calculations were made relative to the ease of extractions in the two systems. These calculations show that the extraction of diphenylhexane from docosane with furfural, and the extraction of acetone from benzene with water would be most satisfactory at low

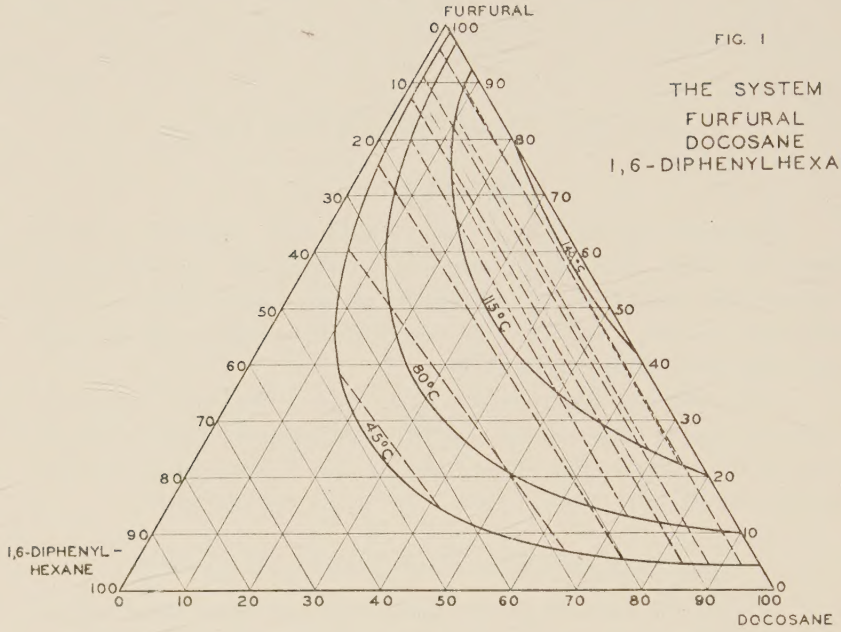

FIG. 1

THE SYSTEM
FURFURAL
DOCOSANE
1,6-DIPHENYLHEXANE

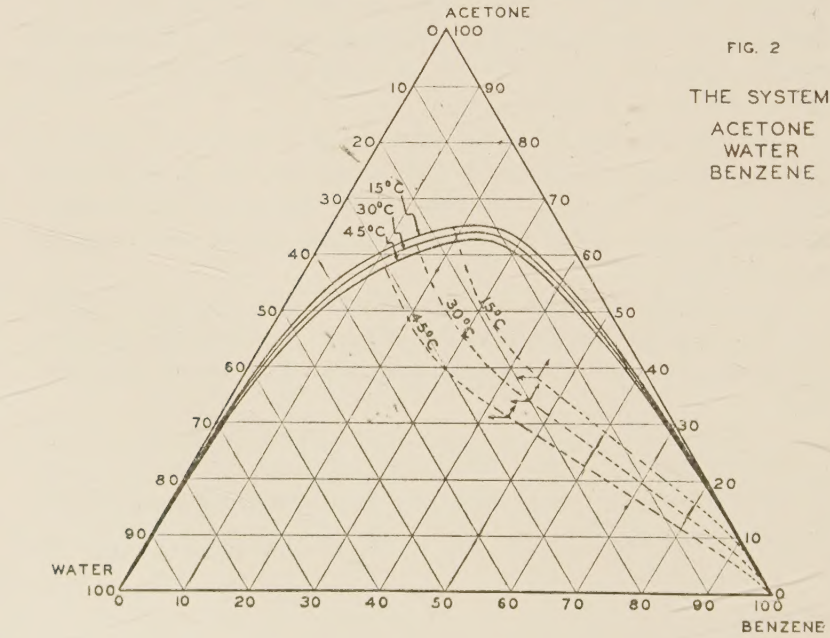

FIG. 2

THE SYSTEM
ACETONE
WATER
BENZENE

temperatures, but that the extraction of acetone from water with benzene would be most satisfactory at high temperatures.

Performance of Extraction Equipment

The rates of transfer of acetic acid, benzoic acid, and aniline between aqueous and benzene phases were studied at various combinations of superficial velocities of the two phases. The experimental apparatus consisted of a 2.15 cm x 74 cm wetted-wall column,[2] a 2.15 cm x 11 cm wetted-wall column, a 4.8 cm x 11.7 cm packed column and a 18.0 cm x 11.7 cm packed column. One-half inch porcelain saddle packing was employed.

The results of the extractions in the wetted-wall columns indicate that the resistances to mass transfer in both phases were proportional to the square root of the superficial velocity in the dispersed (aqueous) phase. Increasing the superficial velocity of the continuous (benzene) phase decreased the resistance in that phase slightly, but had practically no effect on the resistance in the dispersed phase.

The performances of the packed columns studied were best correlated by the following type of equation:

$$Ka = C\ V_d^{0.5}\ V_c^{0.25}$$

where Ka = coefficient of mass transfer

C = constant

V_d = superficial velocity of dispersed phase

V_c = superficial velocity of continuous phase

The ratio of the resistances to mass transfer in the two phases was independent of the rates of flow in the two phases.

The performance of the two types of columns may be compared in the case of the extraction of 0.02 N Benzoic acid from water with benzene, benzene being the continuous phase. In the 4.8 cm x 11.7 cm packed column, transfer coefficients ranged from 10.7 to 34.1 $\frac{\text{(lb.) (mols)}}{\text{(cu. ft.) (hr.) } \frac{\text{(lb. mols)}}{\text{(cu. ft.)}}}$ when superficial velocities varied over the approximate range 10-100 $\frac{\text{(cu. ft.)}}{\text{(sq. ft.) (hr.)}}$. Flooding velocities were reached by this range. The cor-

responding coefficients for the same extraction in the 2.15 cm x 11.8 cm wetted wall column vary from 38.7 to 65.4 when the superficial velocities vary over the approximate range 100-400.

References

1. Alexejew: Wied. Ann. *28,* 305, (1880).
2. Fallah, Hunter, Nash: Soc. Chem. Ind. *53,* 369T, (1934).
3. Sherwood, T. K.: "Absorption and Extraction." McGraw-Hill Company, Inc., New York, Chapt. 8.

VITA

The author was born July 21, 1914 in Troutdale, Oregon. He was graduated from Jefferson High School, Portland, in June, 1932. He has attended as an undergraduate Lingnan University and California Institute of Technology, and was graduated from the latter institution in June, 1937, with the degree of Bachelor of Science. He was admitted to the Graduate School of the University of Illinois in September, 1937. In October, 1938 he received the degree of Master of Science. He has held an Assistantship in Chemical Engineering from September, 1939 to the present, January, 1941.

Digitized by the Internet Archive
in 2026

https://archive.org/details/IA41549820_0038